Dust in the disk winds from young stars as a source of the circumstellar extinction

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Abstract. We examine a problem of the dust grains survival in the disk wind in T Tauri stars (TTSs). For consideration we choose the disk wind model described by Garcia et al. (2001), where a gas component of the wind is heated by an ambipolar diffusion up to the temperature of the order of 10^4 K. It is shown that the dust grains heating due to collisions with the gas atoms and electrons is inefficient in comparison with heating by the stellar radiation, and thus, dust survives even in the hot wind component. Owing to this, the disk wind may be opaque for the ultraviolet and optical radiation of the star and is capable to absorb its noticeable fraction. Calculations show that at the accretion rate $\dot{M}_a = 10^{-8} - 10^{-6} M_\odot$ per year this fraction for TTSs may range from 20% to 40% of a total luminosity of the star correspondingly. This means that the disk wind in TTSs can play the same role as the puffed inner rim considered in the modern models of accretion disks. In Herbig Ae stars (HAEs) inner regions of the disk winds ($r \leq 0.5$ AU) are free of dust since there dust grains sublimate under the effect of the radiation of the star. Therefore, in this case a fraction of the absorbed radiation by the disk wind is significantly less, and may be compared with the effect of the "puffed-up inner rim" only at $\dot{M}_a \geq 10^{-6} M_\odot$ yr^{-1}. Due to the structural inhomogeneity of the disk wind its optical depth towards an observer may be variable resulting in the photometric activity of the young stars. For the same reason, one can observe moving shadows from the gas and dust streams with the spiral-like structure on the highly resolved circumstellar disk images.

1   Introduction

The disk wind plays a clue role in the process of removing the angular momentum excess from accretion disks (Blandford and Payne 1982 (BP82)), and works towards the accretion of the disk matter towards the star. A physical connection between accretion and outflow processes is confirmed by a decrease of the outflow activity with the age of stars, accompanying with a decrease of accretion rates (Calvet et al. 2000) and a frequency of accretion disks (see André et al. (2000); Mundy et al. (2000).)

Most of the modern models (see., e.g., review by Pudritz et al. (2007)) suggest that the disk wind does not contain the dust. Nevertheless, already in 1993 Safier (1993a) in his generalized version of the BP82 self-similar wind model argued that the weakly ionized wind arising from the accretion disk surface lifts the dust grains due to their collisions with the

neutral atoms, i.e. the disk wind is dusty. According to Safier, the maximum size of the grain which are capable to lift with the wind is about of 1 mm.

Apparently, the presence of the dust in the disk wind has to affect the circumstellar (CS) extinction, the spectral energy distribution and polarization properties of the young stellar objects. Based on the results of Safier (1993a), in our previous papers (Grinin and Tambovtseva 2002; Grinin et al. 2004; Tambovtseva et al. (2006)) we consider photometric effects produced by the dusty disk winds in the young binaries. In the present paper we consider in more details than in the cited papers an interaction of the dust component of the wind with the radiation of the star as well with the hot gas for the single TTSs and HAEs.

2 Choice of the disk wind model

2.1 Observational data

In more details, observational manifestation of the disk wind was investigated in TTSs, in whose spectra the wind was responsible for an origin of some spectral lines, including such forbidden lines as [O I] $\lambda 6300 \AA$, [S II] $\lambda 6731 \AA$ and some others (Solf and Böhm 1993; Hirth et al. 1994, 1997; Hartigan et al. 1995). From these line profiles two wind components have been distinguished: a high velocity component (HVC) (the jet, 200-400 km/s), which forms in the nearest to the star regions of the accretion disk, and a low velocity component (LVC) (5-40 km/s) forming at the periphery regions of the disk (Kwan and Tademaru 1995). Such separation, however, rather conventional: studies of the rotational jet velocities revealed an intermediate wind component provided the poloidal velocities of the order of 100 km/c (Bacciotti et al. 2000; Lavalley-Fouquet et al. 2000; Coffey et al. 2004; Woitas et al. 2005).

The presence of the HVC and LVC of the disk wind is especially spectacular on the images of HH 30. This young star is surrounded by the CS disk seen nearly edge-on; as a result, in the visible part of the spectrum a direct radiation of the star is completely absorbed by the disk. Visual images of HH 30 obtained with the Hubble Space Telescope distinctly demonstrate highly collimated jet propagating in the direction perpendicular to the disk plane with the mean velocity of about 300 km/s. Observations in the CO molecule lines showed (Pety et al. 2006) that in the same direction a slow biconical outflow was observed with the typical velocity of about 12 km/s and the open angle of about 30 degrees. The mass loss rate in the biconical outflow estimated by these authors was $\sim 6.3 \cdot 10^{-8} M_\odot$ per year, while that in the jet was less by about two orders of magnitude ($\sim 10^{-9} M_\odot$ per year). Hence it follows, that a bulk of the kinetic energy of the disk wind ($L_w \approx 6 \cdot 10^{31}$ erg/s) comes to acceleration of the matter in the narrow collimated jet, while the main mass loss falls to the low velocity wind component. Such a conclusion agrees well with results of the numerical MHD simulations (Goodson et al. 1999).

2.2 Theoretical models

According to Blandford and Payne (1982), processes of acceleration and tap of the matter in the disk wind are governed by the magnetic field of the accretion disk. If magnetic fields lines threading a thin rotating disk make an angle ϑ with the symmetry axis of the disk $\geq \vartheta_0$ ($\vartheta_0 = 30°$), then the disk matter will be accelerated under the effect of the Lorentz force and the magneto-centrifugally driven wind can be launched. If the disk is threaded by the open field lines from some internal radius r_i to some external radius r_e, then one has a typical scheme of the extended disk wind for which different self-similar solutions have been obtained with the help of magnetohydrodynamics (Königl 1989; Wardle and Königl 1993; Ferreira and

Pelletier 1995; Ferreira 1997; Casse and Ferreira 2000; Ferreira and Casse 2004)[1]. There is the parameter $\xi = d \log \dot{M}_a(\varpi)/d \log \varpi$ which is a measure of the disc ejection efficiency and regulates relation between low-velocity and high velocity wind components, (here $\dot{M}_a$ is the accretion rate, ϖ the distance from the disk symmetry axis). Calculations show that the best agreement with the observed parameters of the forbidden lines in the spectra of TTSs occurs at $\xi \approx 0.007$-0.01 (Cabrit et al. (1999), Garcia et al. 2001a). Below in calculations we use the model "A" from the paper by Garcia et al. (2001a) where the parameter $\xi = 0.01$.

2.3 The model of the dust mixture

During the evolution, the dust component of the protoplanetary disk undergoes essential changes: the dust grains grow and gradually settle towards the disk midplane (Safronov 1972; Weidenschilling 2000). Further, they form solids and planetezimals. However, in the surface layers of the disk small grains of an approximately original (i.e. interstellar) chemical composition persist during a long time. Results of photometric observations of UX Ori type stars testify this. A violent photometric activity of these stars is caused by the changes in the CS extinction due to the small inclination of their CS disks relatively to the line of sight (see review of Grinin (2000) and papers cited there). The data on the selective CS absorbtion, which is observed in these stars during their fading show that the reddening law is close to the interstellar one (see, e.g., Pugach 2004). Since the disk wind starts from the surface of the CS disk we operate below with the MRN mixture (Mathis et al. 1977). Along with this, we also consider the dust grains with the radius equal to $a = 0.1$ μm which provide the reddening law close to that given by the MRN mixture.

3 The dust survival in the gas component of the wind

As it was shown by Safier (1993a,b), an ambipolar diffusion (the ion-neutral drift) is an important source of the gas heating in the disk wind of TTSs. Under the effect of this mechanism the accelerated gas is heated up to the temperature of about 10^4 K. In the wind regions nearest to the star one can also expect an essential contribution from the X-ray radiation to the gas heating (see., e.g. Glassgold et al. 2000), whose major part originates in the shocks during infall of the accretion gas onto the star. The question arises: can the dust grains survive contacting with the heated gas?

3.1 Collisions with the gas atoms. Thermal effect

When the gas particles collide with the dust grains, a part of their kinetic energy converts into the heat resulting in the dust heating. An efficiency of such a process depends on the sort of particles (atoms, ions, electrons) and is determined by the relation (see, e.g. Draine 1981):

$$Q_{coll} = \pi a^2 \sum_i n_i (\frac{8kT_i}{\pi m_i})^{1/2} 2kT_i < \alpha_i >$$

(1)

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[1]There is so-called X-wind model where the wind is launched from one annulus located in the inner disk (Shu et al. 1994; Shang et al. 2002); in this model the disk does not possess the large scale magnetic field, and the main role is assigned to the magnetosphere of the star. In the framework of this model some modern observational facts are not reproduced (see., e.g. Ferreira et al. 2006, Coffey et al. 2004).
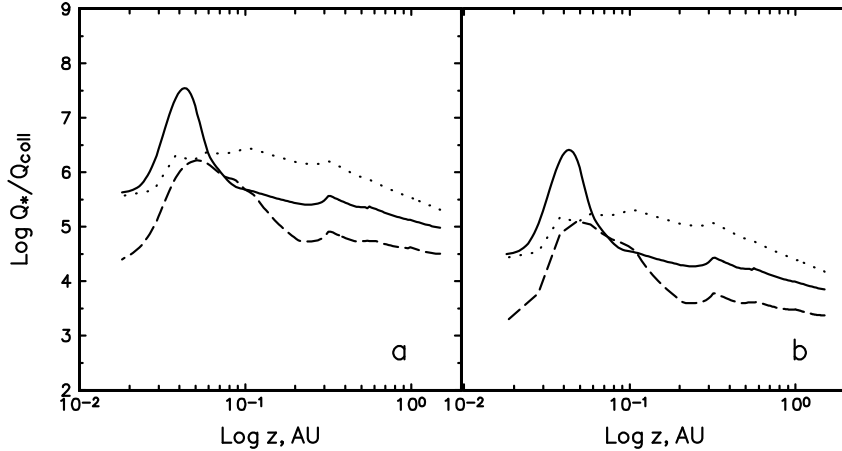
Figure 1: A ratio of the heat power by the radiation of the star to that by dust-gas collisions along the streamline with the anchor at $\varpi_0 = 0.1$ AU, the grain radius is 0.1 μm, (a) graphite, (b) astrosilicate. The accretion rate is equal to $10^{-6} M_\odot$ per yr. (dashed line), $10^{-7} M_\odot$ per yr. (solid line) and $10^{-8} M_\odot$ per yr. (dots).

Here n_i, m_i and T_i are number densities, masses and kinetic temperatures of gas species i, a is the radius of the dust grain, $< \alpha_i >$ the mean fraction of the kinetic energy which is converted to heat when a particle i impacts the grain, k the Boltzmann's constant.

Let us consider an efficiency of this mechanism in comparison with heating of the dust grains by the stellar radiation. An energy absorbed by the dust grain can be written as

$$Q_* = \frac{\pi a^2}{4\pi r^2} \int_0^\infty L_*(\lambda)\, Q_{abs}(\lambda)\, d\lambda, \tag{2}$$

where r is the spherical radius, $L_*(\lambda)$ the luminosity of the star at the given wavelength λ, Q_{abs} the absorption efficiency factor for the grains of the given radius and chemical composition.

The ratios of Q_*/Q_{coll} for two sorts of the dust grains (graphite and astronomical silicate) are shown in Figs. 1 and 2. The grain radius is equal to 0.1 μm. The effective temperature T_{eff} and the radius R_* of the star are equal to 4000 K and $2.5 R_\odot$ respectively. The spectral energy distribution of the star is described by the Planck function. Calculations are made for two streamlines: the innermost one with the start coordinate in the disk plane $\varpi_0 = 0.1$ AU and an outer streamline with $\varpi_0 = 1$ AU. The medium was assumed to be optically thin for the stellar radiation. Optical characteristics of the dust were calculated with the Mie theory. The optic constants were taken from the paper by Draine (1985).

One can see that in the both cases the dust heating due to collisions with atoms and free electrons in the disk wind is negligible in comparison with that by the radiation of the star. Only in those wind regions where the radiation of the star is strongly diluted due to the absorbtion by the dust component of the wind, heating due to collisions may be dominant. But even there cooling of the dust due to the radiation is an efficient process and the grain temperature is far from the sublimation one. As shown by Safier (1993a), the opposite process (the gas cooling by the dust) plays an important role in the base of the wind but in the higher wind layers is less effective than the adiabatic cooling.

Thus, the hot gas in the disk wind and the cold dust can exist in the same regions of the medium, and there is no any paradox or contravention of the thermal dynamics laws. The
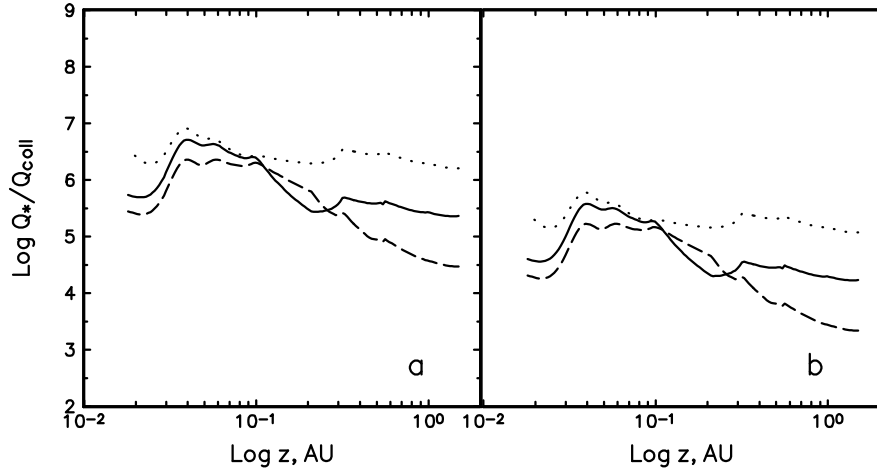
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Figure 2: The same as in Fig. 1 but for the streamline with $\varpi_0 = 1$ AU

reason is that the disk wind is transparent or semi-transparent for the thermal radiation of the dust grains and, therefore is not a close system in the thermodynamical sense.

3.2 Dust sputtering and sublimation

A dust grain can dissipate in the *sputtering* process, when molecules are ejected from the grain after the latter collides with gas particles; this leads to the destruction of the grain. In this case the mass loss by the dust particle is

$$\frac{dm}{dt} = -m_s \sum_i N_i Y_i, \tag{3}$$

where N_i is the number of particles of species i impacting the dust grain in the unit of time, $m_s = \mu_s m_H$ the mass of the molecule leaving the grain, μ_s its molecular weight, Y_i sputtering yield, i.e. the number of molecules released after impact by the particles of the given species. The value of Y_i strongly depends on the energy of colliding particles (Draine and Salpeter 1979). According to these authors, at the energy of the incident atoms of about 1 ev , the sputtering yield is equal to zero both for silicate and graphite. The same is valid for the "chemical" sputtering (Draine 1979).

Thus, the main process affected the dust survival in the disk wind is the sublimation of the dust in the radiation field of the star. As mentioned above, Safier (1993a) and Gracia et al. (2001) determined the dust sublimation zone in the disk winds of TTSs: this is a region extended approximately to 0.1 AU from the central source. In the case of HAEs the sublimation zone is greater. From our calculations it is about 0.5 AU for the model adopted below. Therefore, the inner regions of the disk wind in HAEs are free of dust.

4 Disk wind and circumstellar extinction

Assuming that the disk wind has an axial symmetry we estimated the portion of the total luminosity of the star which can be absorbed and scattered by the dust component of the wind, and the disk inclination angles under which the wind becomes transparent for the

radiation of the star. The first of these parameters (we call it as screening coefficient) is determined as follows:

$$\delta = \frac{1}{L_*} \int_0^\infty L_*(\lambda)\, d\lambda \int_0^{\pi/2} (1 - e^{-\tau_0(\lambda,\theta)}) \sin\theta\, d\theta \tag{4}$$

Here L_* is a bolometric luminosity of the star (as above we assume the Planck spectrum), θ an angle between an arbitrary radius-vector $\vec{r}$ and the symmetry axis of the disk; $\tau_0(\lambda, \theta)$ the optical depth of the disk wind at the wavelength λ in the $\vec{r}$ direction.

Calculations of τ_0 have been made for the MRN mixture at dust to gas ratio 1:100 that is typical for the interstellar medium. The gas density distribution in the TTS's wind was taken as mentioned above. The same model was used for the disk wind in HAEs. For this purpose we used scaling given in the Garcia et al (2001a) (relations (9)) connecting the disk wind parameters with the mass of the star and the accretion rate. For HAEs we adopt $M_* = 2.5 M_\odot$. Two other parameters needed for calculation of the sublimation radius are the stellar luminosity ($L_* = 50 L_\odot$) and the effective temperature ($T_{ef} = 9000$ K).

Results of the δ calculations for different values of the accretion rate in the range of $\dot{M}_a$ = 10^{-9} - $10^{-6} M_\odot$ per year are shown in Fig. 3. It is seen that for TTSs the value of δ changes in the range from about 0.1 at $\dot{M}_a = 10^{-9} M_\odot$ yr^{-1} to ≈ 0.4 at $M_a = 10^{-6} M_\odot$ yr^{-1}. This means that at $M_a \geq 10^{-8} M_\odot$ yr^{-1} *the dust component of the disk wind can absorb and scatter a noticeable fraction of the stellar radiation producing thus an expanding shadow zone in the adjacent regions of the CS disk.*

Figure 3 presents also results of the analogues calculations for graphite - silicate mixture with proportions as in Draine and Lee (1984) and with the fixed radius ($a = 0.1$ μm). Such a mono-dispersed mixture will be used in the further paper in simulations of the infrared radiation of the disk wind, since in the visual and near infrared regions of the spectrum it has optical characteristics very close to that of the MRN mixture. It is indirectly confirmed by Fig. 3: it is seen that this mixture provides almost the same screening effect by the disk wind as the MRN mixture.

Calculations of the thermal balance of the graphite and silicate grains with the radius a = 0.1 μm showed that for Herbig Ae stars with adopted L_* and T_{ef}, the sublimation radius is equal to 0.35 AU for graphite particles and 0.75 AU for silicate ones. Taking this into account we calculated optical depths in the disk wind τ_0 and coefficient of screening δ for HAEs. It is seen from Fig. 3 that an absence of dust in the inner part of the disk wind in HAEs notably decreases a solid angle within which the radiation of the star can be absorbed and scattered by the dust component of the wind: a maximum value of δ (at $\dot{M}_a = 10^{-6} M_\odot$ yr^{-1}) is about 0.15; this is less by $\sim$ factor of 3 than that for TTSs at the same $\dot{M}_a$ but comparable with the effect produced by the puffed-up inner rim in the dust sublimation zone (Natta et al. 2001).

Figure 4 shows angles θ_1 between the disk plane and the line of sight at which the optical depth of the disk wind τ is equal to unity at wavelengths $\lambda = 0.5$ and 0.1 μm. The former is close to the maximum of the V - band path, the latter is close to the wavelength of the L_α - line which plays an important role in the energetics of the ultraviolet spectra of the young stars. Calculations are fulfilled for MRN mixture. It is seen that in TTSs the angle θ_1 at which $\tau_{\lambda_{0.5}} = 1$ ranges from 8 to 37 degrees depending on the accretion rate. In HAEs the corresponding values of θ_1 are notably less because of the existence of the inner region in the disk wind free of dust.

At $\lambda = 0.1 \mu$m the extinction coefficient of the MRN mixture is three times greater than that at $\lambda = 0.5 \mu$m. As a result, the angle θ_1 corresponded to $\tau_{\lambda_{0.1}} = 1$ increases. For TTSs it reaches 12 - 45 degrees at accretion rates $10^{-9} - 10^{-6} M_\odot$ per year respectively. Calculated
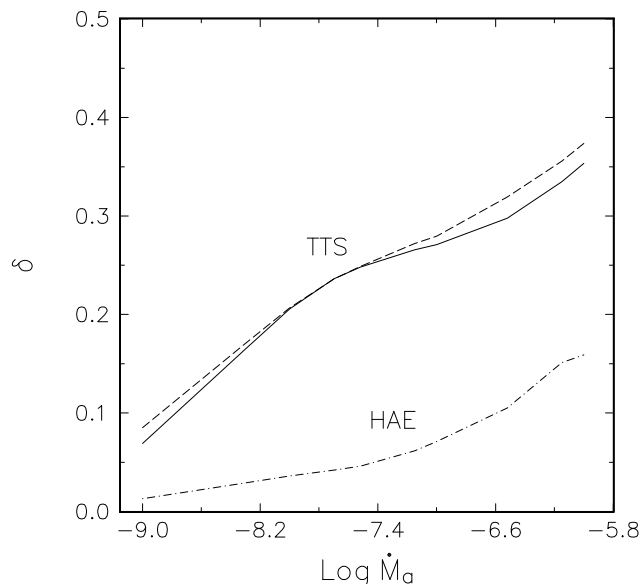
Figure 3: The coefficient of screening of the stellar radiation by the dusty disk wind vs. $\dot{M}_a$. Solid line: the MRN mixture, dashed line: the mono-dispersed mixture with radius 0.1 μm (both curves relate to the disk wind in TTSs), dashed-dotted line: the mono-dispersed mixture with the radius 0.1 μm for the disk wind in HAEs.

utmost angles show under which inclinations of the CS disks to the line-of-sight one can see ultraviolet and optical spectra of the young stars undisturbed by the absorption in the disk wind.

Figure 5 shows contours of the disk wind in TTSs calculated under the condition that the vertical optical depth $\tau_\perp$ measured from the disk surface inwards is equal to unity. Calculations have been made for three wavelengths: 0.1, 0.5 and 3 μm for the wind model with $\dot{M}_a = 10^{-6} M_\odot$ per year and MRN dust. The wavelength 3μm corresponds to the effective wavelength of the infrared radiation originated in the regions of the CS disk nearest to the star. At this λ a mayor part of the disk wind is transparent for the radiation. Therefore, its boundary at 3 μm is close to the surface of the standard flared disk (e.g., Kenyon and Hartmann 1987; Dullemond and Natta 2003) determined as $H/r \approx 0.1$, where H is the scaling height at the distance r. In the visual and especially in the ultraviolet spectrum regions the effective optical depth of the disk wind increases, and one has to take into account this circumstance when modelling the spectral lines arising in the dense wind layers (such as, for example, ultraviolet molecules H_2).

5 Discussion

Thus, we showed that in the case of T Tauri stars the disk wind can absorb and scatter the radiation of the star within a rather large segment of the solid angle 4π in the wide range of the accretion rates $\dot{M}_a = 10^{-8} - 10^{-6} M_\odot$ yr^{-1}. This means that the disk wind, in fact, is capable to play the same role as the puffed-up inner rim in the dust sublimation zone of the accretion disk (Natta et al. 2001). This inner rim screens the adjoining regions of the accretion disk from the direct stellar radiation (Dullemond et al. 2001), and under the certain inclination angles of the disk to the line of sight may be a source of the variable CS extinction (Dullemond et al. 2003). The dust component of the disk wind is able to produce
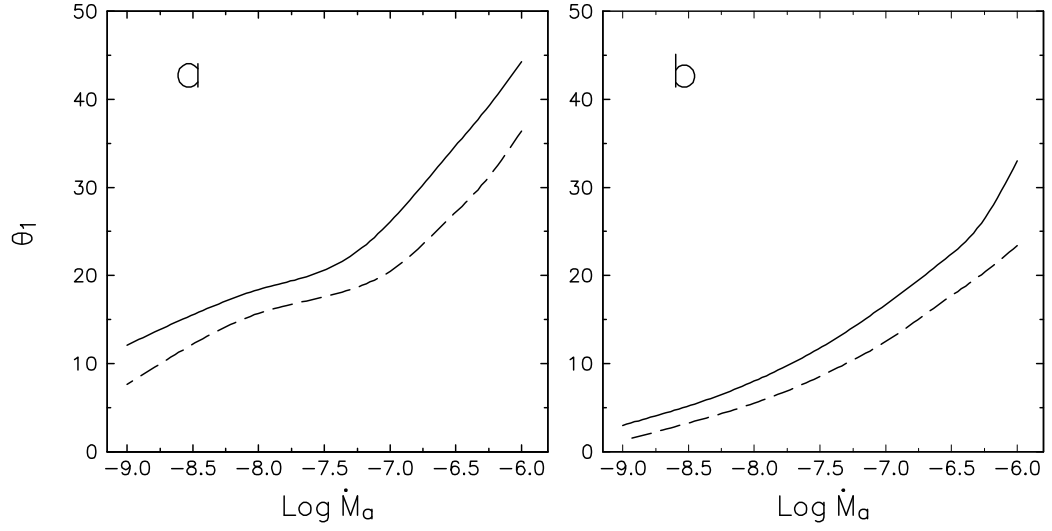
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Figure 4: An angle between the disk plane and the line of sight at which the optical depth of the disk wind is equal to unity at the wavelength $\lambda = 0.5\mu$m (solid) and 0.1μm (dashed) **a)** for TTSs, **b)** - for HAEs. See the text for details.
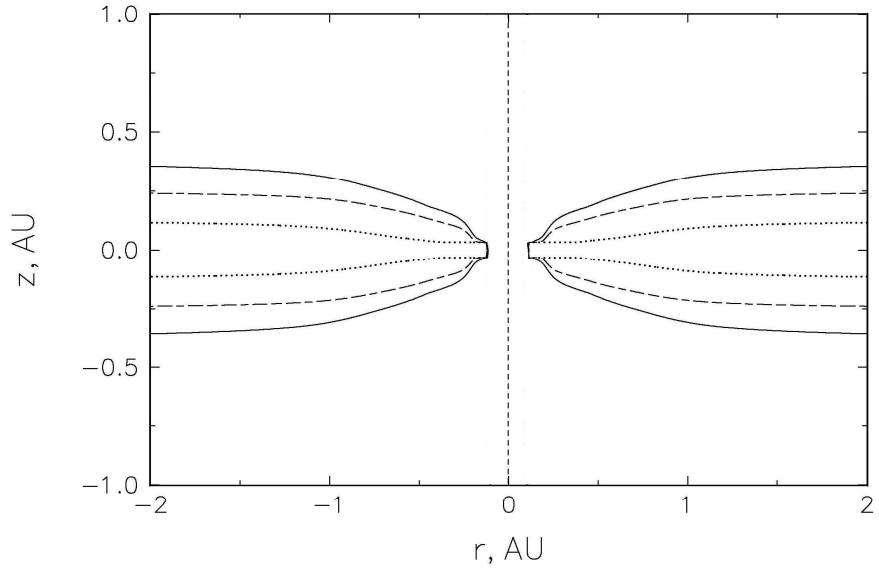

Figure 5: Contours of the TTSs' disk wind at $\tau_\perp = 1$ at the wavelengths 0.1μm (solid line) and $0.5mu$m (dashed line). The accretion rate $\dot{M}_a = 10^{-6}M_\odot$ per year.

the same effect.

In the case of Herbig Ae stars a screening effect produced by the dust component of the disk wind at the same range of accretion rates is significantly less than that for TTSs. Therefore, in HAEs the contribution of the disk wind into the thermal radiation of the CS dust can be comparable with that from the inner rim only at the high values of the accretion rate $\geq 10^{-6} M_{\odot}$ yr^{-1}.

It should be noted that we considered optical properties of the dust component of the wind using the model of Garcia et al (2001) with $\xi = 0.01$. In the disk wind theory this important parameter governs an efficiency of the magneto centrifugal mechanism of the gas acceleration. In particular, a growth in ξ leads to an increase of the mass loss rate in the disk wind as well to a decrease of the terminal velocity of the wind (Garcia et al. 2001). Both effects works in the same direction: they increase the density of the matter in the wind. Therefore in the models with the large ξ the disk wind has to be more opaque on dust in comparison with the model considered above.

5.1 Structural disk wind and variable circumstellar extinction

Basing on the existing disk wind models we suggested that the wind possesses an axial symmetry and azimuthal homogeneity. In fact, this is a model simplification, and in reality, it seems hardly feasible. In conditions of supersonic turbulent motions the disk wind cannot be a continuous outflow in the hydrodynamical sense. It has to consist of an aggregate of gas and dust streams of the different power arising from the disk surface. In such a case the filling factor q would be one of the wind parameters. It implies a fraction of the wind volume filled in with streams of the matter. Now we can only note that q has to be less than unity.

Thus, under the real conditions, the column density of the dust along the line of sight passed through the disk wind, may be a complex function of time. It may fluctuate due to the motion of the gas and dust streams. Besides its changes can reveal quasi-periods caused by the repeated intersection of the line of sight by the same dominant wind stream. Note, that the quasi-periods in the brightness changes have been really observed in some UX Ori type stars (see e.g., Shevchenko et al. 1993). The rotation of the nonhomogeneous disk wind could be the reason of the spectral variability of some young stars (e.g. Kozlova et al. 2003).

Changes in the CS extinction may vary not only the radiation flux coming to the observer directly from the star, but the radiation flux from that region of the disk which is illuminated by the star through the disk wind. Shadows from the wind in this part of the CS disk have to move along the disk following the motion of the gas and dust streams. Since these streams looks like spinning-up spirals, their shadows projected on the disk have to be also spiral-like. Detection and investigation of such moving shadows on the images of the CS disks would be important for the theory of the disk winds.

HH 30. It is likely that namely such a mechanism of the variability is realized in the case of HH 30. Comparison of the images of this object obtained in the different time with the Hubble Space Telescope showed that they are variable. Both the type of the object's asymmetry and the integral flux from it were variable (Burrows et al. 1996; Stapelfeldt et al. 1999, Wood et al. 2000). Wood and Whitney (1998) supposed that changes in conditions of illumination of the CS disk by the spotted rotating star could be the reason of the HH 30 variability. However, new data on the variability of the object (Watson and Stapelfeldt 2004, 2007) did not confirm the presence of the period connected with the rotation of the spotted star. According to these authors, variability of HH 30 has a more complex character and caused by changes in the CS extinction in the inner regions of the disk. A structural disk wind consisted of the separate gas and dust streams starting from the surface of the CS

disk corresponds well to this role.

RW Aur. Another example of the young star whose variability is difficult to explain without appealing to a hypothesis about a dusty disk wind is the classical TTS RW Aur. This star relates to the most studied young stars. It is characterized with a large amplitude photometric activity (Herbst et al. 1994) and a complex type of variability of the emission line profiles and intensities (Petrov et al. 2001; Alencar et al. 2005). Recently Petrov and Kozak (2007) analyzed in detail a long-term series of the spectral and photometric observations of RW Aur and showed that there is a correlation in variations in the emission lines with the different excitation potential, which can be explained only if to assume that spectral variability is due to screening the emission region by the CS dust clouds. It is known from observations that the symmetry axis of the RW Aur's CS disk is inclined to the line of sight under 46 ±3° (this angle was derived very accurately with the help of the radial and space (a projection on the sky plane) velocities of the moving details in the optical jet (Lopez-Martin et al. 2003)). Under such an inclination disk cannot screen the star even if to take into account the rim in the sublimation zone. Therefore, an appearance of the dust on the line of sight (and hence, on the high latitudes in the star's coordinate system) Petrov and Kozak connected with the dust fragments of the disk wind.

An applicability of the theory of the dusty disk winds is not limited by examples given above. The calculations show (Grinin and Tambovtseva 2002; Tambovtseva et al. 2006) that the photometric effects caused by the dust component of the disk wind can be observed in the young binaries. In particular, obscuration by the extended disk win could cause abnormally long lasting eclipses observed in some binaries.

6   Conclusion

Let us briefly summarize results of the analysis given above.

1. Basing on the disk wind model described by Garcia et al. (2001) we showed that the dust grains carrying away by the gas component of the wind survive being in the contact with the hot (10^4 K) gas.

2. The range of the solid angles which is covered by the part of the wind opaque by dust depends on the accretion rate and the luminosity of the star, and for TTSs may amount a noticeable fraction of the full solid angle 4π. This means that the disk wind can notably contribute both to the scattered radiation at the optical and ultraviolet wavelengths, and to the infrared excesses of the radiation of T Tauri stars.

3. Conditions of the disk wind formation are such that it cannot be a continuous axially-symmetric outflow; it is rather an agglomerate of the gas and dust streams started from those points of the circumstellar disk where the conditions for the matter acceleration by the magnetic field are most favorable. A motion of the matter in the disk wind results in the variations of the dust column density on the line of sight. Therefore, under certain inclination of the disk to the line of sight the gas and dust streams of the disk wind can cause the variable CS extinction resulting in the photometric activity of the young stars. For the same reason one can see moving shadows on the CS disks images caused by gas and dust streams arising from the disk surface.

4. Herbig Ae stars have the sublimation radius at about 0.5 AU from the central source. As a result, the inner densest part of the disk wind is free of dust, and the effective solid angle within which the dust wind component can interact with the radiation of the star is small compared to 4π. Nevertheless, even in such a case a periphery region of the wind may be a source of the variable CS extinction, responsible for the photometric activity of UX

Ori type stars. Therefore, dense in time photometrical monitoring of these stars may give a valuable information on the disk wind structure in the acceleration zone in the close vicinity to the surface of the accretion disk.

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